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(54) **AUXILIARY CONTROL WITH DIAGNOSTIC CAPABILITY**

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(58) **Field of Search** ..... 701/36, 110; 237/5, 237/12.3 B, 12.3 C, 12.3 R; 180/53.1; 307/29, 38; 123/142.5 E, 142.5 R

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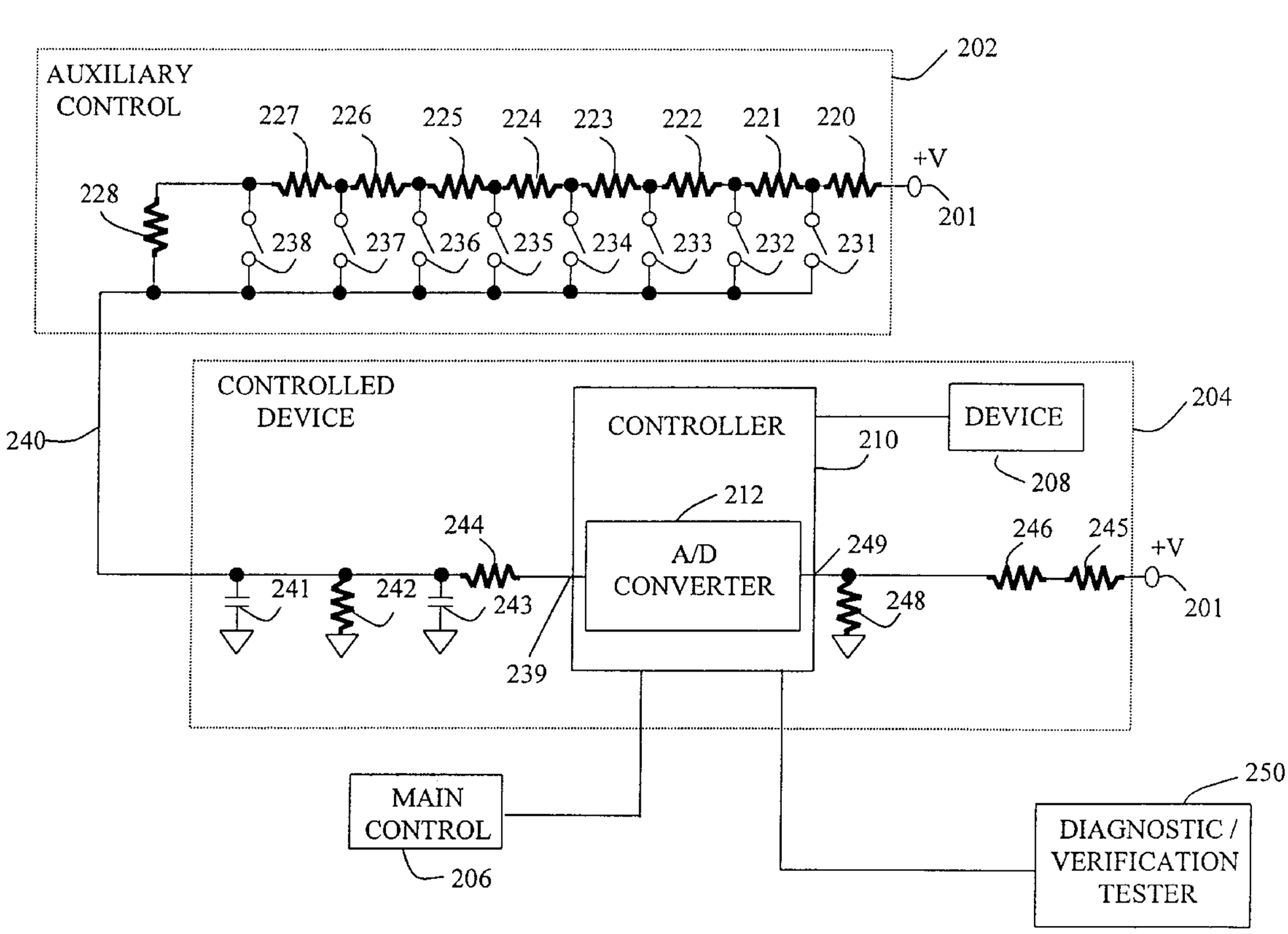
(57) **ABSTRACT**

A control system automatically determines the presence of an auxiliary control. The system includes a controlled device and a main control. The controlled device includes a main control input and an auxiliary control input. If an auxiliary control is present, a discernible non-zero default signal is supplied on the auxiliary control input of the controlled device, when no inputs of the auxiliary control are asserted. This advantageously allows for the verification of correct assembly (i.e., determination of the presence or non-presence of an auxiliary control) without technician intervention.

19 Claims, 2 Drawing Sheets



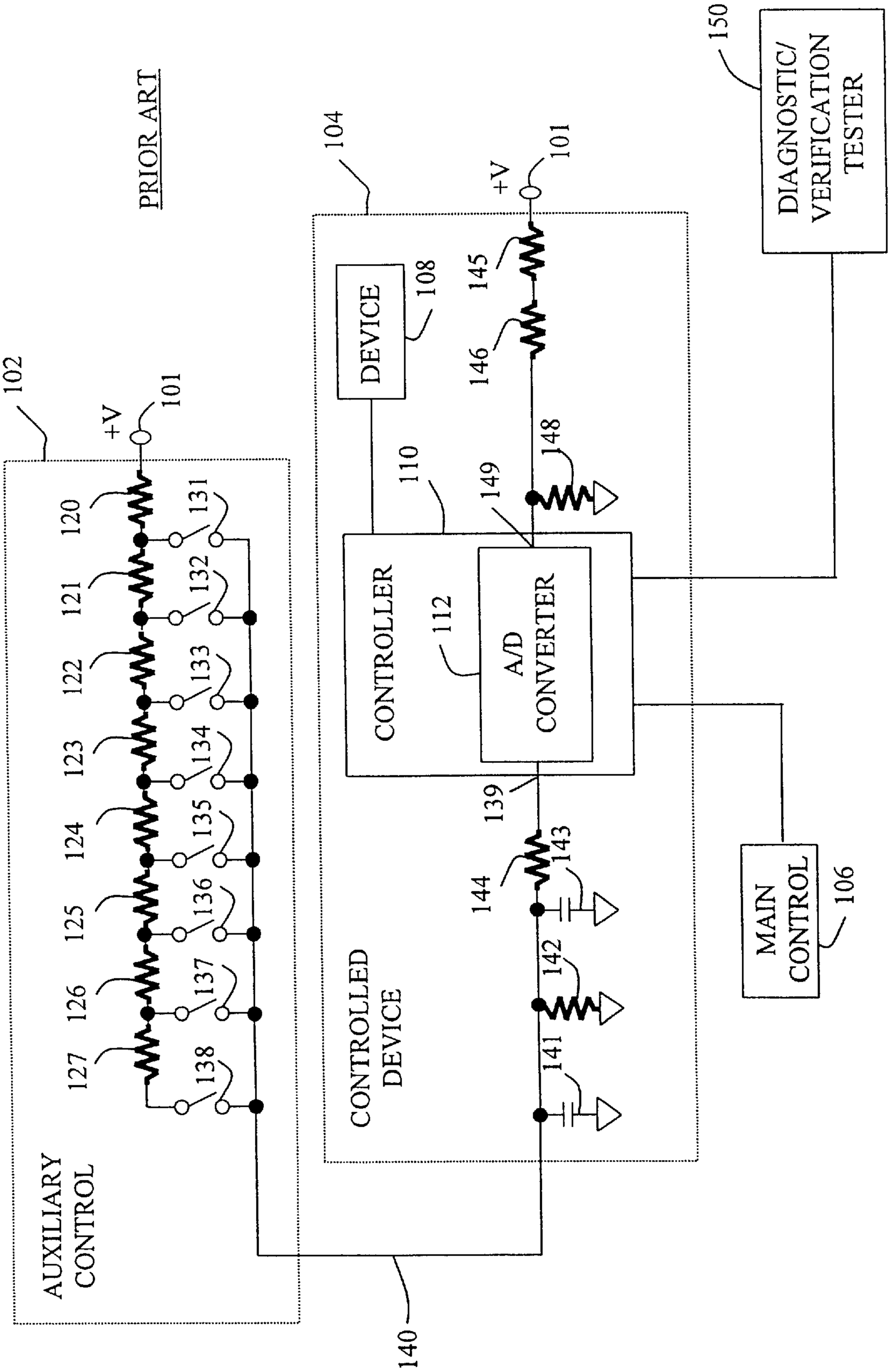

PRIOR ART
AUXILIARY CONTROL
102
+V
101
120
121
131
132
122
133
123
134
124
135
125
136
126
137
127
138
104
+V
101
DEVICE
108
145
146
148
110
149
CONTROLLER
112
A/D CONVERTER
CONTROLLED DEVICE
139
144
143
142
141
140
150
DIAGNOSTIC/ VERIFICATION TESTER
MAIN CONTROL
106

FIG. 1

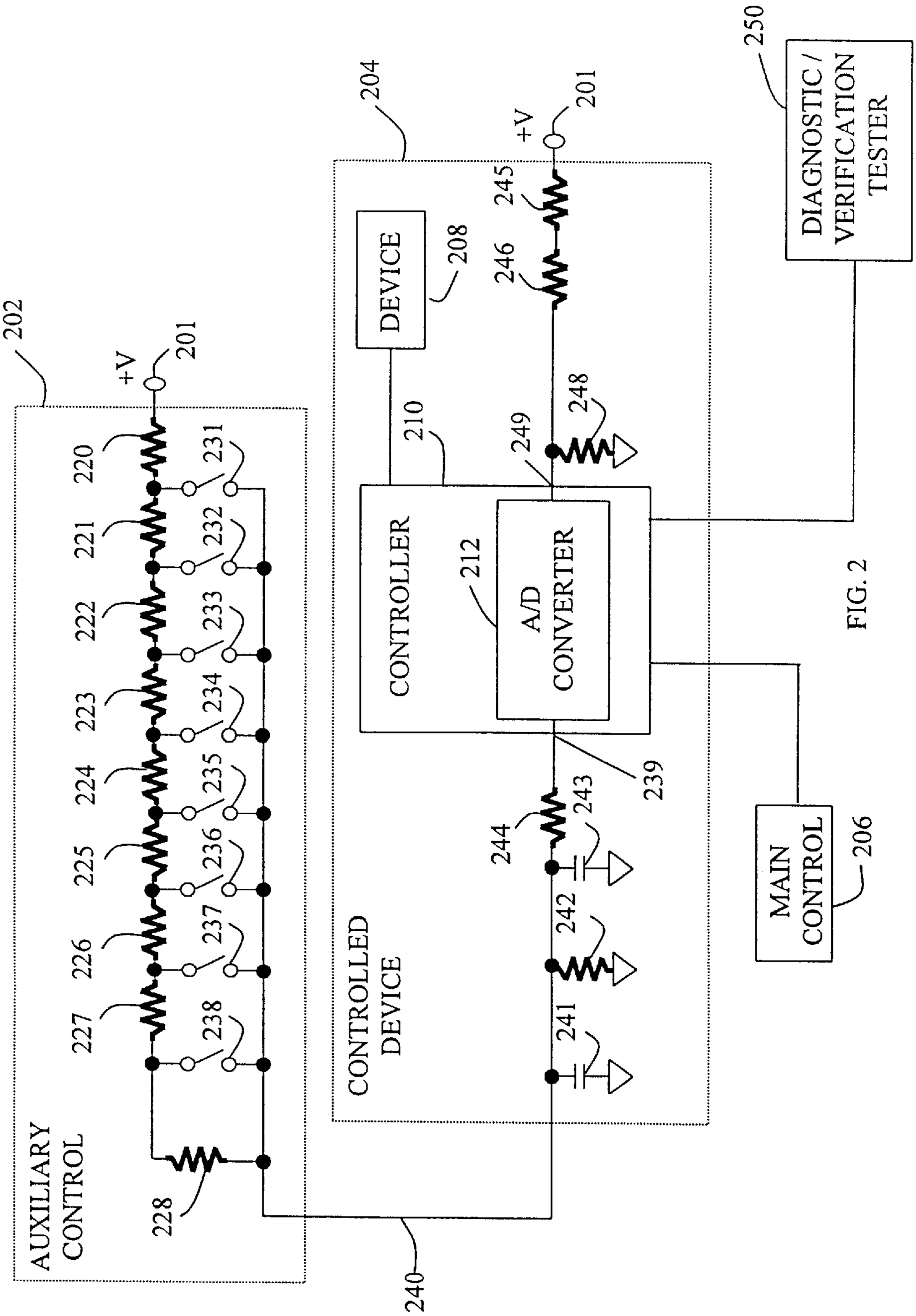

AUXILIARY CONTROL
202
+V
201
220
221
231
232
222
233
223
234
224
235
225
236
226
237
227
238
228
CONTROLLED DEVICE
204
+V
201
245
246
DEVICE
208
210
248
249
CONTROLLER
212
A/D CONVERTER
239
244
243
242
241
240
250
DIAGNOSTIC / VERIFICATION TESTER
MAIN CONTROL
206

FIG. 2

AUXILIARY CONTROL WITH DIAGNOSTIC CAPABILITY

TECHNICAL FIELD

The present invention is directed to an auxiliary control, and more specifically to an auxiliary control that provides for automated diagnostics.

BACKGROUND OF THE INVENTION

Today, many automobiles include auxiliary controls that are located for operator convenience. These controls are often mounted in the steering wheel or within reach of a rear seat passenger to allow for remote control of a controlled device (e.g., an automotive entertainment system (e.g., a radio receiver) or heating ventilation and air conditioning (HVAC) system). Many of these auxiliary controls are based on a simple resistive divider network that provides a unique voltage to a controller for each button (i.e., switch) that is asserted. When no button is asserted, a typical auxiliary control provides a signal of zero volts (i.e., ground) to the controlled device on an auxiliary control input. Unfortunately, when such an auxiliary control is installed, a diagnostic/verification tester cannot determine if the auxiliary control is connected without technician intervention. In a typical situation, a technician has to physically activate a button (i.e., a switch of the auxiliary control) in order for the tester to determine if the auxiliary control is present.

As such, a technique for automatically detecting the presence of an auxiliary control, without human intervention, is desirable to verify correct assembly.

SUMMARY OF THE INVENTION

The present invention is directed to a method and system that automatically determines the presence of an auxiliary control. A controlled device includes a main control input and an auxiliary control input. If an auxiliary control is present, a discernible non-zero default signal is provided on the auxiliary control input of the controlled device when no inputs of the auxiliary control are asserted. This advantageously allows for the verification of correct assembly (i.e., determination of the presence or non-presence of an auxiliary control) without technician intervention.

These and other features, advantages and objects of the present invention will be further understood and appreciated by those skilled in the art by reference to the following specification, claims and appended drawing's.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will now be described, by way of example, with reference to the accompanying drawings, in which:

FIG. **1** is an electrical schematic and block diagram of a control system according to the prior art; and

FIG. **2** is an electrical schematic and block diagram of a control system, according to an embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

To facilitate the verification of the presence of an auxiliary control without technician intervention, an auxiliary control

is modified to present a non-zero default signal (i.e., a non-zero voltage) to a controlled device when no input of the auxiliary control is asserted. The auxiliary device can be, for example, an automotive entertainment system (e.g., a radio receiver) or a heating ventilation and air conditioning (HVAC) system. Utilizing the e approach described herein, the software of the controlled device is modified to indicate the presence of an auxiliary control if a non-zero default t signal is present at an auxiliary control input. This allows a diagnostic/verification tester, located at an assembly/manufacturing plant, to interrogate the controlled device through a serial vehicle bus to determine if the auxiliary control is present. The diagnostic/verification tester can then determine whether the automobile has been assembled in conformance with a vehicle manifest. In this manner, the diagnostic/verification tester can determine whether an auxiliary control is present without technician intervention.

Referring to FIG. **1**, a prior art auxiliary control **102** is shown coupled to a controlled device **104**. Also coupled to the controlled device **104** is a main control **106**. In a typical case, main control **106** is coupled to a input/output (I/O) pin of controller **110**. Auxiliary control **102** includes a plurality of resistors **120**, **121**, **122**, **123**, **124**, **125**, **126** and **127**, which are coupled in series and provide a resistive voltage divider. A first end of resistor **120** is coupled to a vehicle ignition switch (not shown) and is supplied with an ignition voltage (+V, through terminal **101**) when the vehicle ignition switch is asserted. A second end of resistor **120** is coupled to a first terminal of switch **131** and a first end of resistor **121**. A second end of resistor **121** is coupled to a first terminal of switch **132** and a first end of resistor **122**. A second end of resistor **122** is coupled to a first terminal of switch **133** and a first end of resistor **123**. A second end of resistor **123** is coupled to a first terminal of switch **134** and a first end of resistor **124**. A second end of resistor **124** is coupled to a first end of resistor **125** and a first terminal of switch **135**. A second end of resistor **125** is coupled to a first end of resistor **126** and a first terminal of switch **136**. A second end of resistor **126** is coupled to a first end of resistor **127** and a first terminal of switch **137**. A second end of resistor **127** is coupled to a first terminal of switch **138**. A second terminal of switches **131**, **132**, **133**, **134**, **135**, **136**, **137** and **138** are connected (by signal line **140**) to controlled device **104**.

A capacitor **141** is coupled between signal line **140** and a ground common to auxiliary control **102** and controlled device **104**. Capacitor **141** acts to suppress electromagnetic interference (EMI). Resistor **142** serves to pull signal line **140** to ground when switches **131**–**138** are all open. Capacitor **143** and resistor **144** act as a low pass filter and provide a signal on signal line **140** to an analog-to-digital (A/D) converter **112**, internal to controller **110**. Resistors **146** and **145** are serially coupled to the ignition voltage (+V) and provide a reference voltage to A/D converter **112**. The ignition voltage is divided by resistors **145**, **146** and **148**. Resistor **148** is coupled between a voltage reference input **149**, of controller **110**, and the common ground.

In a typical automobile, controller **110** is coupled to a serial automotive bus. In this manner, a diagnostic/verification tester **150** can communicate with controller **10** so as to determine whether an auxiliary control **102** is present in an automobile under test. However, when

diagnostic/verification tester **150** provides a command to controller **110** (to determine whether an auxiliary control **102** is present), if none of switches **131–138** are closed, controller **110** cannot determine whether the auxiliary control **102** is present. This is because resistor **142** pulls signal line **140** to ground, when none of switches **131–138** are asserted (i.e., closed). However, when the auxiliary control **102** is not present, resistor **142** also pulls signal line **140** to ground. As such, in order to determine whether an auxiliary control **102** is present during a verification process, a technician must assert at least one of switches **131–138**, of auxiliary control **102**, such that controller **110** can determine if a non-zero signal is present at input **139**. With auxiliary controls of the prior art, the diagnostic/verification tester **150** cannot determine whether an auxiliary control **102** is present in a vehicle without technician intervention.

FIG. **2** shows an auxiliary control **202** coupled to a controlled device **204**, according to an embodiment of the present invention. Also coupled to the controlled device **204** is a main control **206**. Auxiliary control **202** includes a plurality of resistors **220**, **221**, **222**, **223**, **224**, **225**, **226**, **227** and **228**. Resistors **220–228** are coupled in series and provide a resistive voltage divider. A first end of resistor **220** is coupled to a vehicle ignition switch (not shown) and is supplied with an ignition voltage (+V or Vign, at terminal **201**) when the vehicle ignition switch is asserted. A second end of resistor **220** is coupled to a first terminal of switch **231** and a first end of resistor **221**. A second end of resistor **221** is coupled to a first terminal of switch **232** and a first end of resistor **222**. A second end of resistor **222** is coupled to a first terminal of switch **233** and a first end of resistor **223**. A second end of resistor **223** is coupled to a first terminal of switch **234** and a first end of resistor **224**. A second end of resistor **224** is coupled to a first end of resistor **225** and a first terminal of switch **235**. A second end of resistor **225** is coupled to a first end of resistor **226** and a first terminal of switch **236**. A second end of resistor **226** is coupled to a first end of resistor **227** and a first terminal of switch **237**. A second end of resistor **227** is coupled to a first terminal of switch **238** and a first end of resistor **228**. A second end of resistor **228** is coupled to a second terminal of switches **231–238** and to the controlled device **204**, by signal line **240**.

Resistor **228** provides a discernible non-zero default signal on the auxiliary control input of controlled device **204** when the auxiliary control **202** is present and no inputs (i.e., switches **231–238**) of auxiliary control **202** are asserted. Thus, when a diagnostic/verification tester **250** communicates with controller **210** over a serial vehicle bus, controller **210** can read a voltage (i.e., Vaux) at input **239** to deter-mine whether the auxiliary control **202** is present.

A capacitor **241** is coupled between signal line **240** and a ground common to auxiliary control **202** and controlled device **204**. Capacitor **241** acts to suppress electromagnetic interference (EMI). Resistor **242** (R**242**) serves to pull signal line **240** to ground when auxiliary control **202** is not present. Capacitor **243** and resistor **244** act as a low pass filter and provide a signal on signal line **240** to an A/D converter **212**, internal to controller **210**. Resistors **246** and **245** are serially coupled to the ignition voltage (+V or Vign, through terminal **201**) and provide a reference voltage (Vref) to A/D converter **212**. The ignition voltage (Vign) is divided by resistors **245**, **246** and **248** to provide the reference voltage (Vref). Resistor **248** is coupled between a voltage reference input **249**, of controller **210**, and ground. In a typical automobile, controller **210** is coupled to a serial automotive bus.

In this manner, a diagnostic/verification tester **250** can communicate with controller **210** so as to determine whether an auxiliary control **202** is present in an automobile under test. When the diagnostic/verification tester **250** provides an appropriate command to controller **210**. Controller **210** determines whether an auxiliary control **202** is present by reading the voltage at input **239**. If the voltage is approximately equal to a default voltage, the auxiliary control **202** is present. As such, a diagnostic/verification tester **250** can determine whether an auxiliary control **202** is present in a vehicle without technician intervention.

In the system, described above, resistor **228** provides a discernible non-zero default signal on the auxiliary control input of controlled device **204**, when present (with no inputs of auxiliary control **202** asserted). Thus, when diagnostic/verification tester **250** communicates with controller **210** over the serial vehicle bus, controller **210** has a default voltage that it checks for to determine whether the auxiliary control **202** is present.

In a preferred embodiment, controller **210** is a model TMS370, microprocessor manufactured and made commercially available by Texas Instruments. Preferably, resistors **220–228**, **242**, **246** and **248** have a one-percent tolerance. Using resistors with a one-percent tolerance is desirable, as using less accurate components can yield values that are outside of the limits set forth in Table 1. In a preferred embodiment, resistor **220** is a 1300 Ω resistor, resistor **221** is a 280 Ω resistor, resistor **222** is a 357 Ω resistor, resistor **223** is a 475 Ω resistor, resistor **224** is a 665 Ω resistor, resistor **225** is a 1000 Ω resistor, resistor **226** is a 1650 Ω resistor, resistor **227** is a 3160 Ω resistor, resistor **228** is a 8660 Ω resistor and resistor **242** is a 475 Ω resistor. Preferably, resistor **244** is a 22 kΩ resistor and capacitor **243** is a 0.01 μF capacitor. In the preferred embodiment, resistor **245** is 1 kΩ resistor, resistor **246** is 10.5 kΩ resistor and resistor **248** is a 4.75 kΩ resistor.

Table 1, shown below, provides exemplary target codes for each switch of auxiliary control **202** (i.e., S**231–S238**) and exemplary upper and lower limits for each switch. The codes of Table 1 are shown for example only and are based on utilizing an 8-bit A/D converter and resistors with the values disclosed above. A/D converter **212** samples the auxiliary control input (Vaux) provided by auxiliary control **202** and the reference voltage (Vref). As shown below, the ratio of the auxiliary control input and the reference voltage (Vaux/Vref) is multiplied by **255** to determine what switch, if any, is asserted. This is determined by comparing the result to values in the look-up table, as shown in Table 1. If none of the switches are asserted, R**228** provides a non-zero default voltage such that controller **210** can detect the presence of auxiliary control **202**. One of ordinary skill in the art will readily appreciate that modifying component values or tolerances or utilizing a controller that includes an A/D converter with an accuracy different than that of the TMS370 may require variation from the values shown in Table 1.

TABLE 1

Switches	All Open	231	232	233	234	235	236	237	238
Upper Limit	24	240	208	177	148	120	94	69	46
Target	23	234	202	172	144	117	91	67	44
Lower Limit	22	227	196	167	139	113	88	65	43

Example

Basic Equations for Deriving a Target Value for Switch **231**

Vref=Vign*4.75 k/(4.75 k+10.5 k+1.00 k)=0.292*Vign

Vaux=Vign*475/(475+1.30 k)=0.268*Vign: Value for Switch **231**

(Vaux/Vref)*255=(0.268/0.292)*255=234: Target Value for Switch **231**

In summary, controller **210**, using an internal A/D converter **212**, measures a signal (Vaux) on signal line **240**. As previously discussed, if an auxiliary control is not present, resistor **242** pulls the signal line **240** to ground. However, if auxiliary control **202** is present, the addition of resistor **228** provides a discernible non-zero default signal on the auxiliary control input of the controlled device **204**. This allows diagnostic/verification tester **250** to determine the presence of an auxiliary control **204** without requiring a technician to press a switch of auxiliary control **202**.

Preferably, the software for controlled device **204** is written to accept a default value as an indicator of the presence of auxiliary control **202**. In this manner, diagnostic/verification tester **250** can interrogate controlled device **204**, through the vehicle data bus, and determine if auxiliary control **202** is present. Tester **250** can then compare the result with the vehicle manifest to determine if the vehicle conforms to the manifest. Product software does not need to include the codes for determining whether all switches are open as these values can be incorporated within the software of tester **250**. As such, adding the above described detection capability does not increase product memory requirements.

The above description is considered that of the preferred embodiments only. Modifications of the invention will occur to those skilled in the art and to those who make or use the invention. Therefore, it is understood that the embodiments shown in the drawings and described above are merely for illustrative purposes and not intended to limit the scope of the invention, which is defined by the following claims as interpreted according to the principles of patent law, including the Doctrine of Equivalents.

What is claimed is:

1. A method of automatically determining the presence of an auxiliary control, comprising the steps of:

providing a controlled device, the controlled device including a main control input and an auxiliary control input; and

determining whether an auxiliary control is present by examining a signal at the auxiliary control input, wherein the auxiliary control provides a discernable non-zero default signal on the auxiliary control input of the controlled device when the auxiliary control is present and no inputs of the auxiliary control are asserted.

2. The method of claim **1**, wherein the step of determining whether the auxiliary control is present by examining a signal at the auxiliary control input, further includes the step of:

interrogating the controlled device to determine whether the non-zero default signal is present on the auxiliary control input of the controlled device.

3. The method of claim **2**, wherein the controlled device is coupled to an assembly plant verification tester, the tester causing the controlled device to determine whether the default signal is present on the auxiliary control input of the controlled device.

4. The method of claim **3**, wherein the controlled device is coupled to the assembly plant verification tester by a serial vehicle bus.

5. The method of claim **1**, wherein the controlled device is an automotive entertainment system.

6. The method of claim **5**, wherein the automotive entertainment system is a radio receiver.

7. The method of claim **1**, wherein the controlled device is an automotive heating, ventilation and air conditioning (HVAC) system.

8. A control system that automatically provides for the determination of the presence of an auxiliary control, comprising:

a controlled device, the controlled device including a main control input and an auxiliary control input; and

a main control coupled to the controlled device through the main control input, wherein if an auxiliary control is coupled to the auxiliary control input of the controlled device it provides a discernable non-zero default signal on the auxiliary control input of the controlled device when no inputs of the auxiliary control are asserted such that the controlled device can determine its presence.

9. The system of claim **8**, wherein the controlled device is coupled to an assembly plant verification tester, the tester causing the controlled device to determine whether the default signal is present on the auxiliary control input of the controlled device.

10. The system of claim **9**, wherein the controlled device is coupled to the assembly plant verification tester by a serial vehicle bus.

11. The system of claim **8**, wherein the controlled device is an automotive entertainment system.

12. The system of claim **11**, wherein the automotive entertainment system is a radio receiver.

13. The system of claim **8**, wherein the controlled device is an automotive heating, ventilation and air conditioning (HVAC) system.

14. An automotive control system that provides for the automatic determination of the presence of an auxiliary control, comprising:

a controlled device, the controlled device including a main control input and an auxiliary control input, the controlled device performing a function within an automobile; and

a main control coupled to the controlled device through the main control input, wherein if an auxiliary control

is coupled to the auxiliary control input of the controlled device it provides a discernable non-zero default signal on the auxiliary control input of the controlled device when no inputs of the auxiliary control are asserted such that the controlled device can determine its presence.

15. The system of claim **14**, wherein the controlled device is coupled to an automobile assembly plant verification tester, the tester causing the controlled device to determine whether the default signal is present on the auxiliary control input of the controlled device.

16. The system of claim **15**, wherein the controlled device is coupled to the automobile assembly plant verification tester by a serial vehicle bus.

17. The system of claim **14**, wherein the controlled device is an automotive entertainment system.

18. The system of claim **17**, wherein the automotive entertainment system is a radio receiver.

19. The system of claim **14**, wherein the controlled device is an automotive heating, ventilation and air conditioning (HVAC) system.

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